US011301665B2

(12) **United States Patent**
Chung et al.

(10) **Patent No.: US 11,301,665 B2**
(45) **Date of Patent: Apr. 12, 2022**

(54) **FINGERPRINT AND PROXIMITY SENSING APPARATUS AND SENSING PROCESS THEREOF**

(71) Applicant: **Novatek Microelectronics Corp.**, Hsinchu (TW)

(72) Inventors: **Jung-Chen Chung**, Hsinchu County (TW); **Chi-Ting Chen**, Hsinchu (TW)

(73) Assignee: **Novatek Microelectronics Corp.**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 113 days.

(21) Appl. No.: **16/531,126**

(22) Filed: **Aug. 5, 2019**

(65) **Prior Publication Data**

US 2020/0265206 A1 Aug. 20, 2020

Related U.S. Application Data

(60) Provisional application No. 62/808,236, filed on Feb. 20, 2019.

(51) **Int. Cl.**
G06K 9/00 (2006.01)
G06F 21/32 (2013.01)

(52) **U.S. Cl.**
CPC ***G06K 9/0004*** (2013.01); ***G06F 21/32*** (2013.01); *G06K 2009/0006* (2013.01)

(58) **Field of Classification Search**
CPC G06K 9/0004; G06K 2009/0006; G06K 9/20; G06K 9/209; G06K 9/2081; G06F 21/32; G01S 7/4808
See application file for complete search history.

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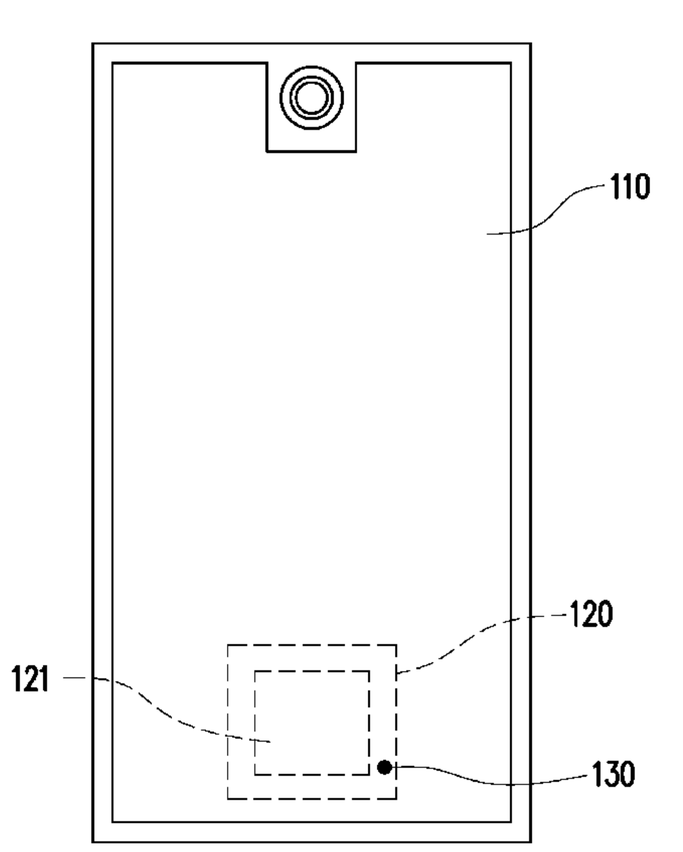
Primary Examiner — Emily C Terrell
Assistant Examiner — Molly Delaney
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

A fingerprint and proximity sensing apparatus for fingerprint recognizing and proximity sensing is provided. The fingerprint and proximity sensing apparatus includes a display panel, a fingerprint sensor, and at least one proximity sensing light emitting diode. The fingerprint sensor has an optical sensing array. The optical sensing array is configured to receive a first light emitted from the display panel and a second light emitted from the at least one proximity sensing light emitting diode at different time periods. The first light and the second light have different ranges of wave length. A sensing process is also provided.

19 Claims, 10 Drawing Sheets



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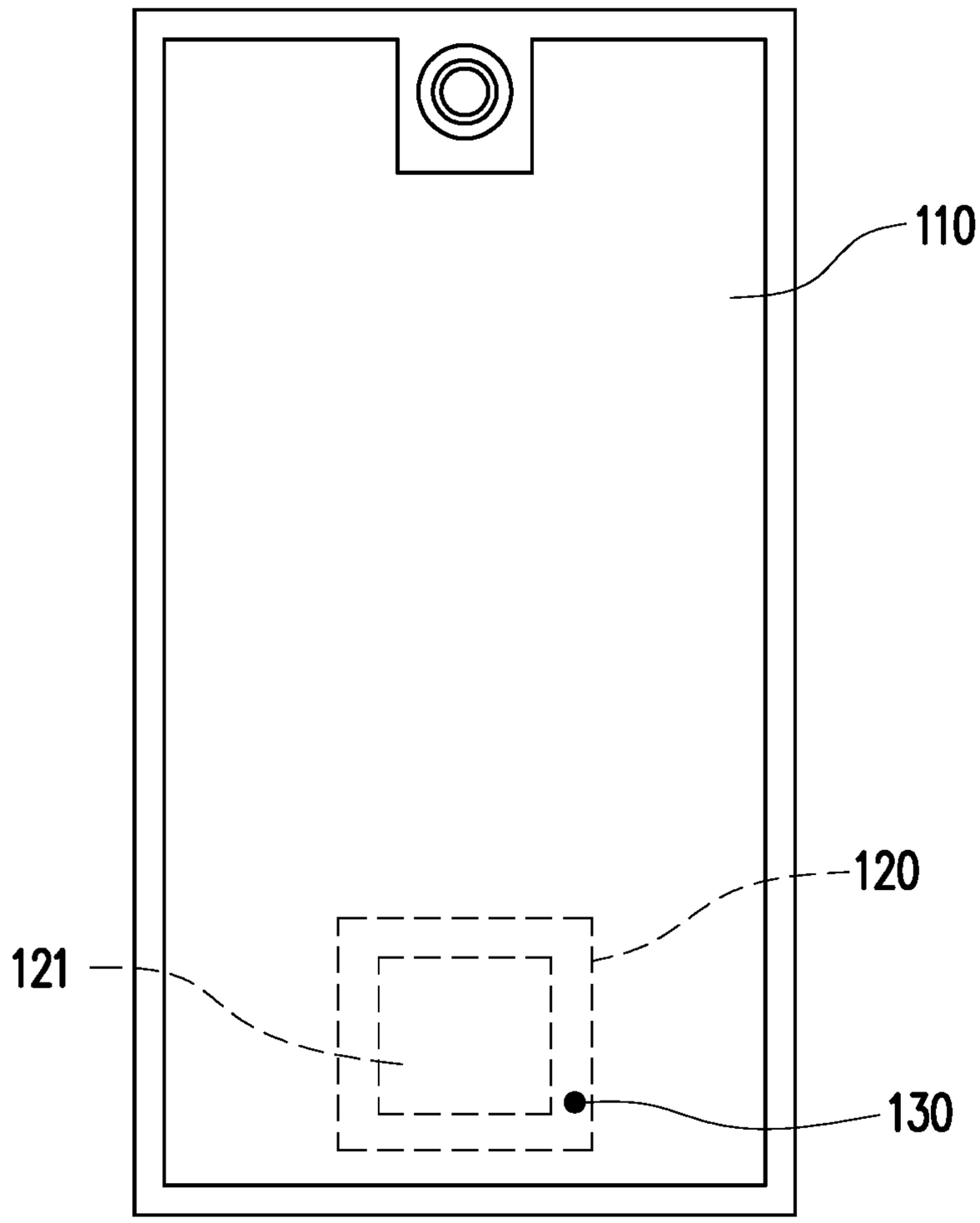

FIG. 1

FIG. 2

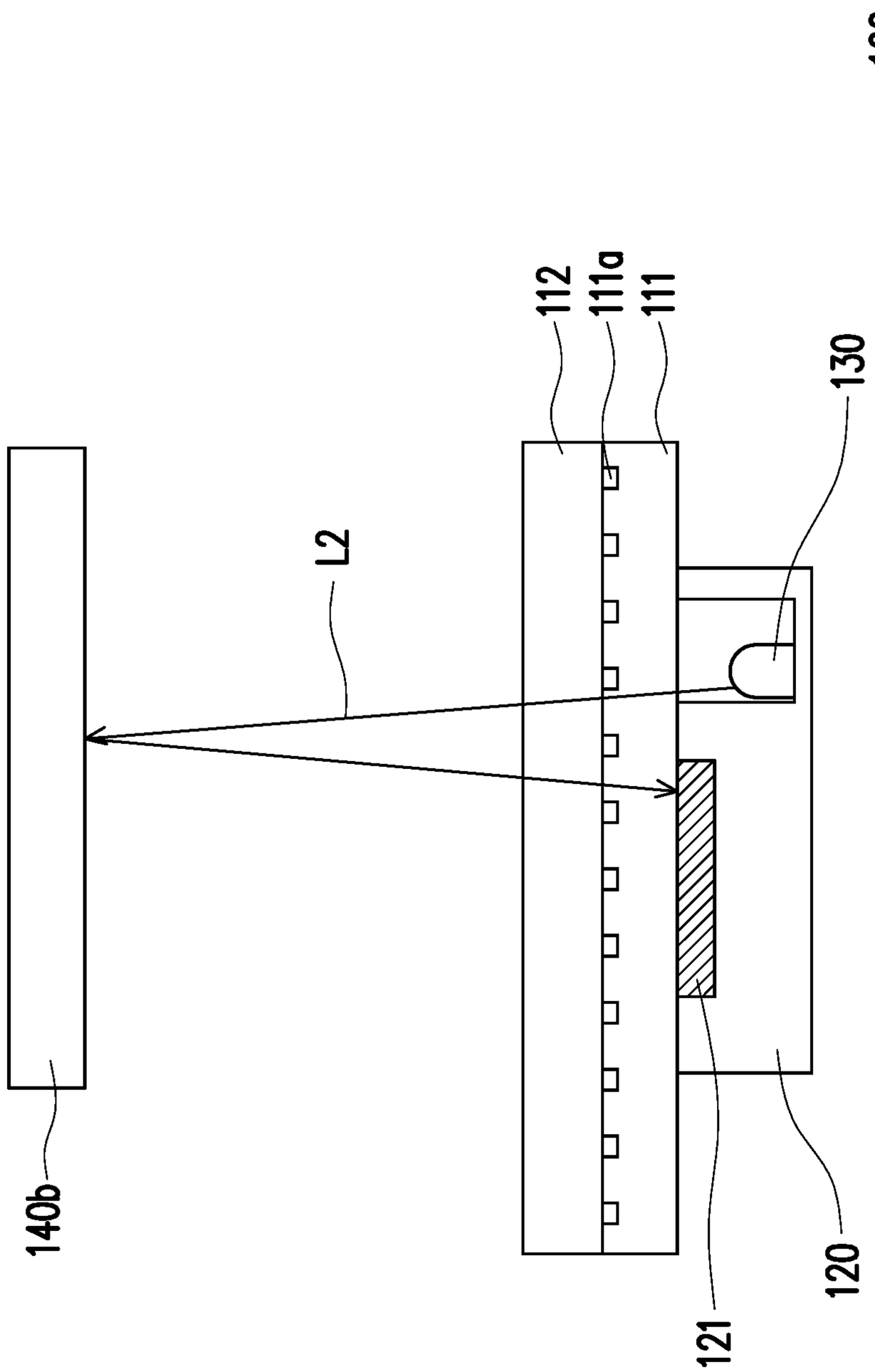

FIG. 3

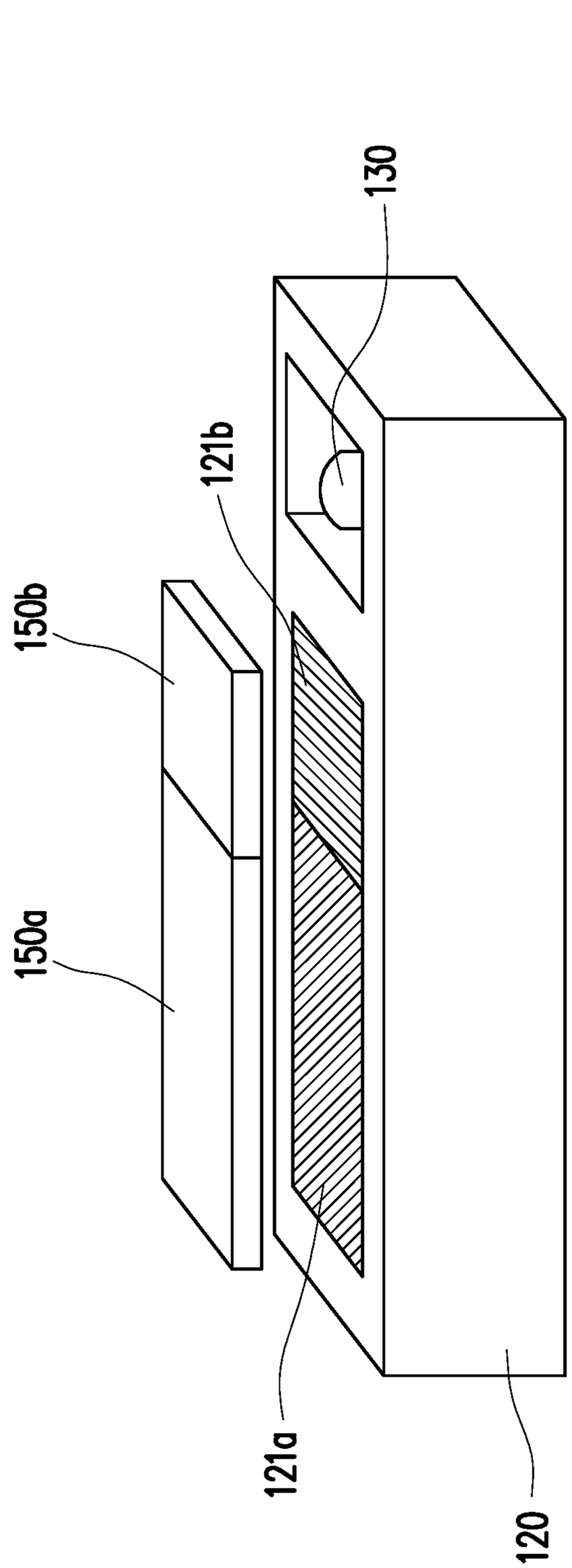

FIG. 4

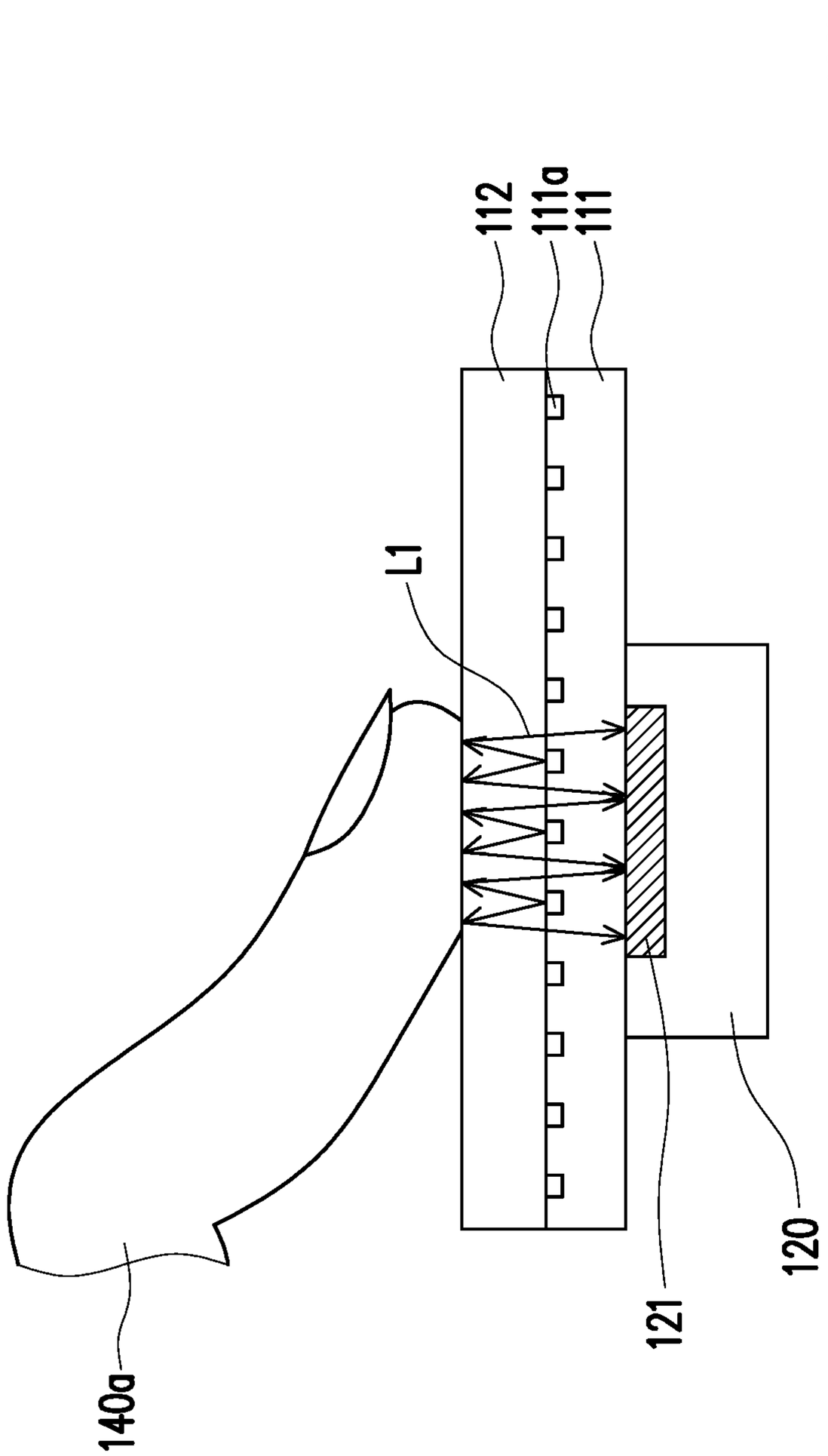

FIG. 5A

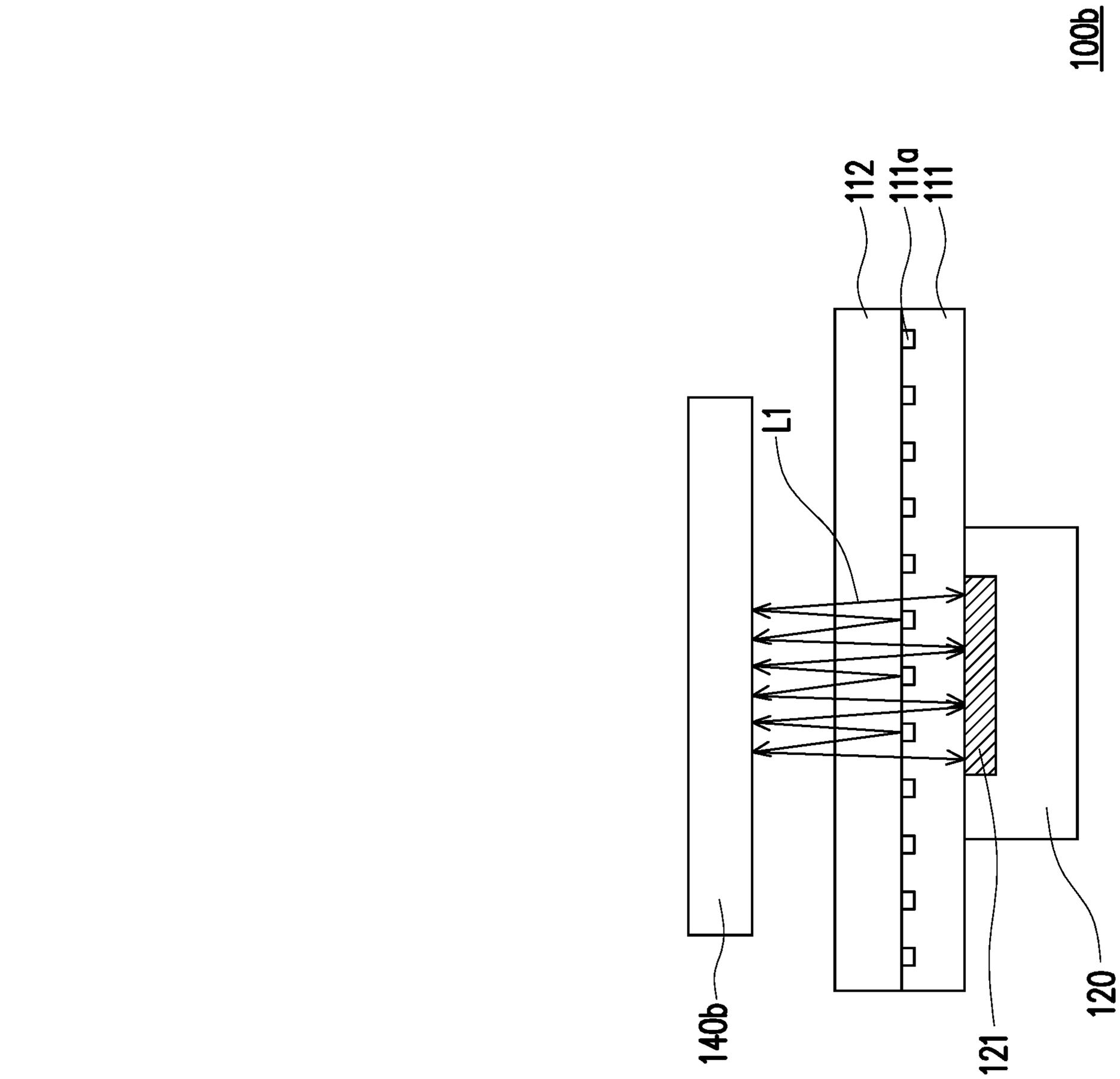

FIG. 5B

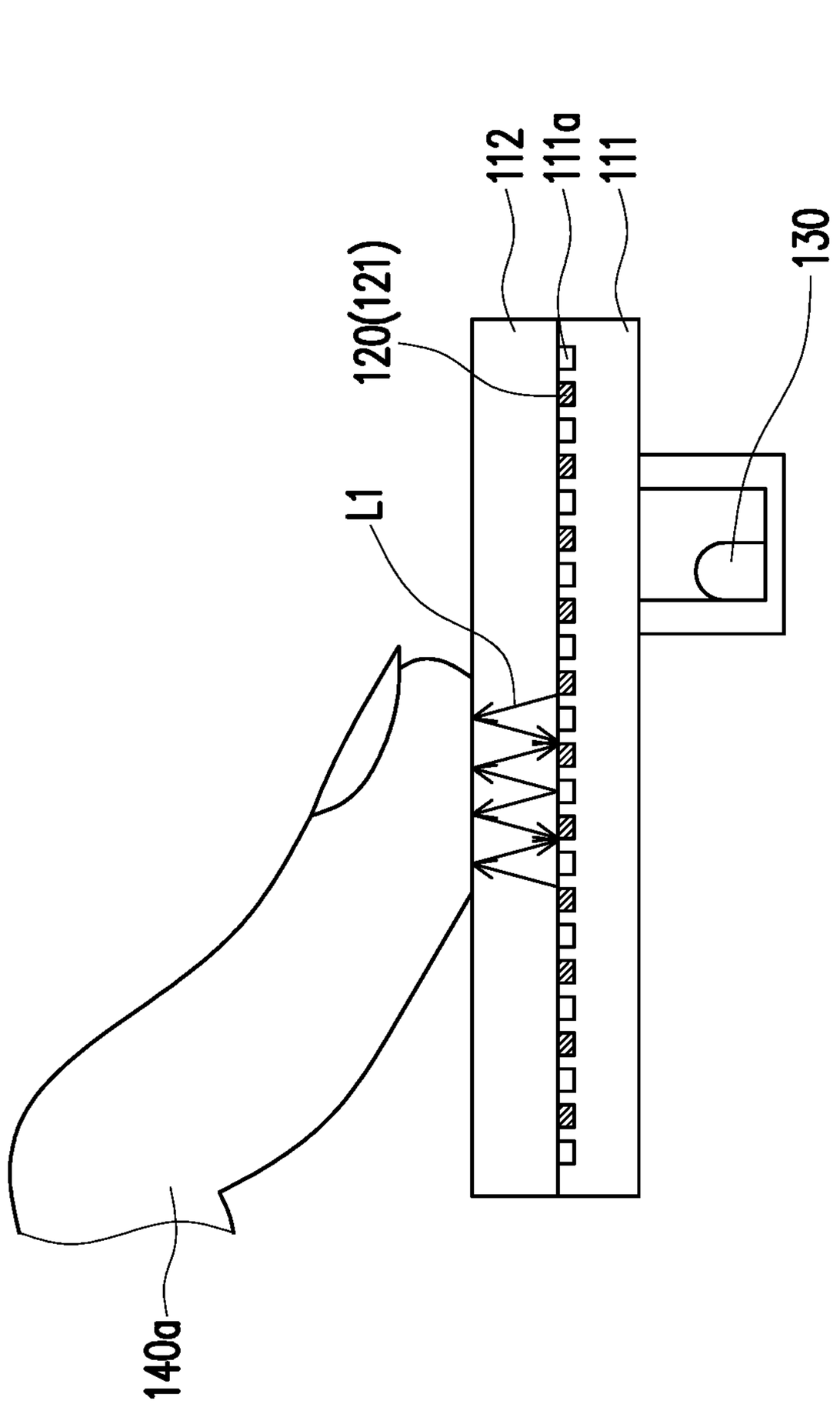

FIG. 6A

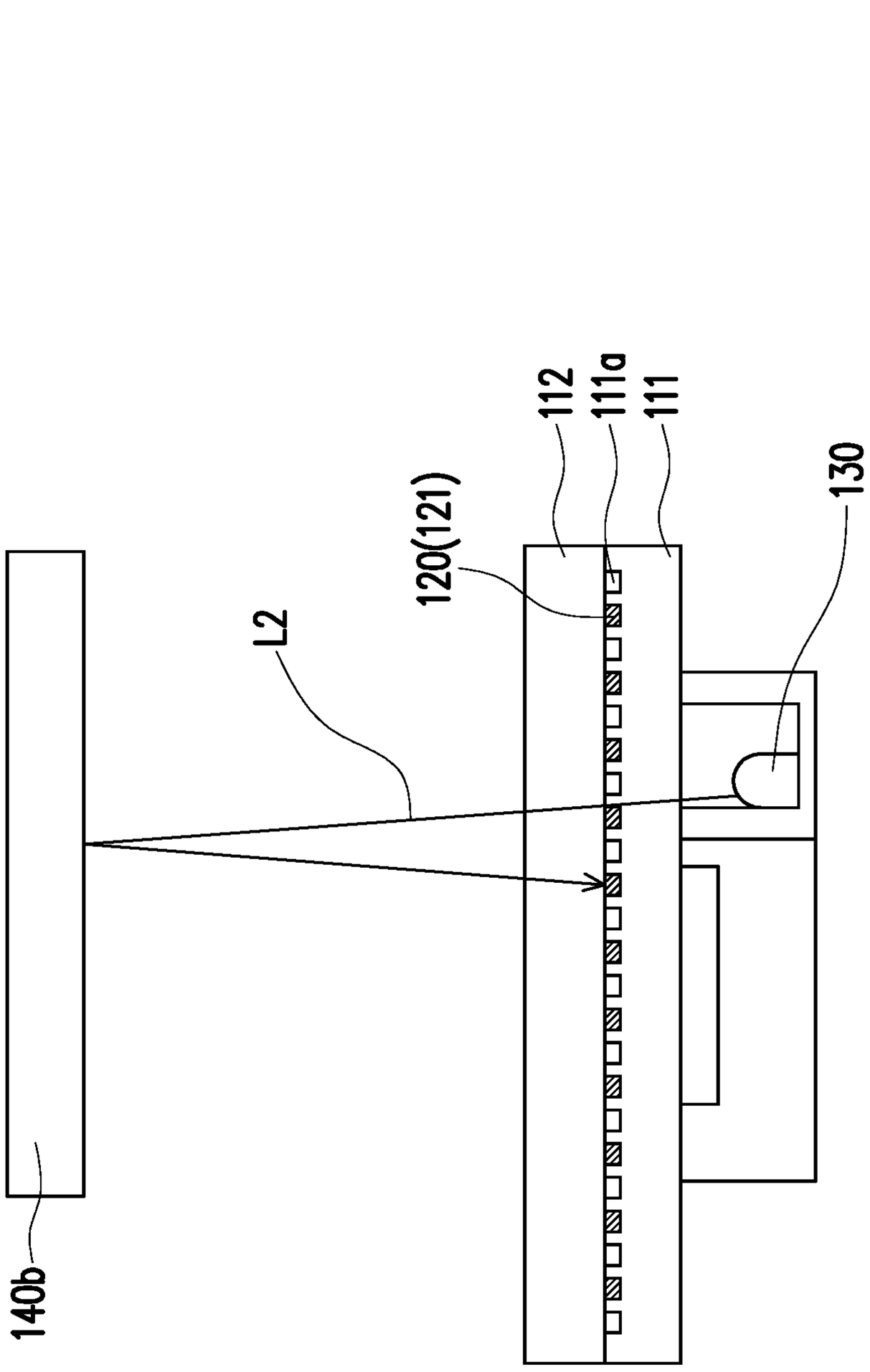

FIG. 6B

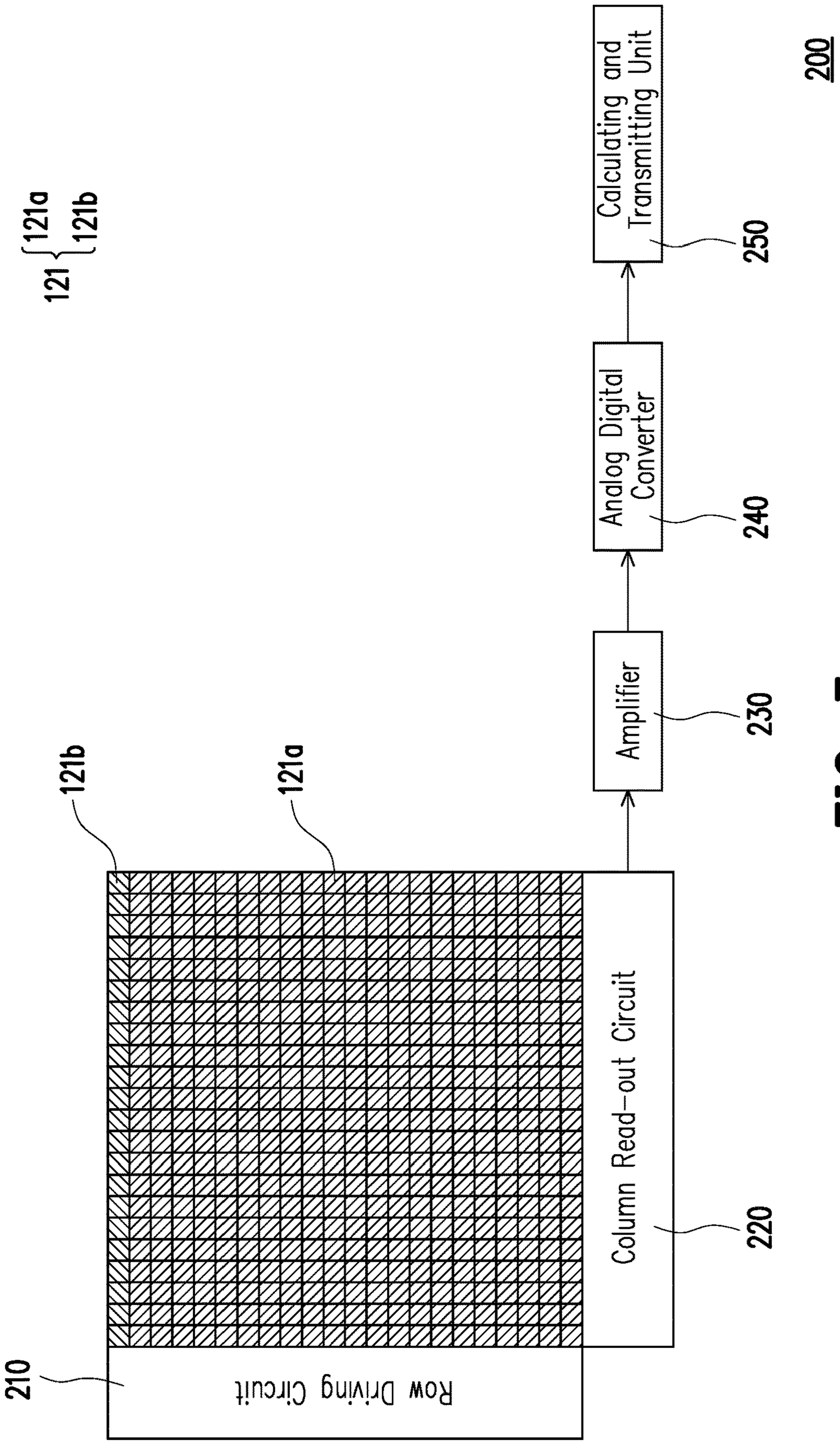
121
121a
121b
200
Calculating and Transmitting Unit
250
Analog Digital Converter
240
Amplifier
230
121b
121a
Column Read-out Circuit
220
Row Driving Circuit
210

FIG. 7

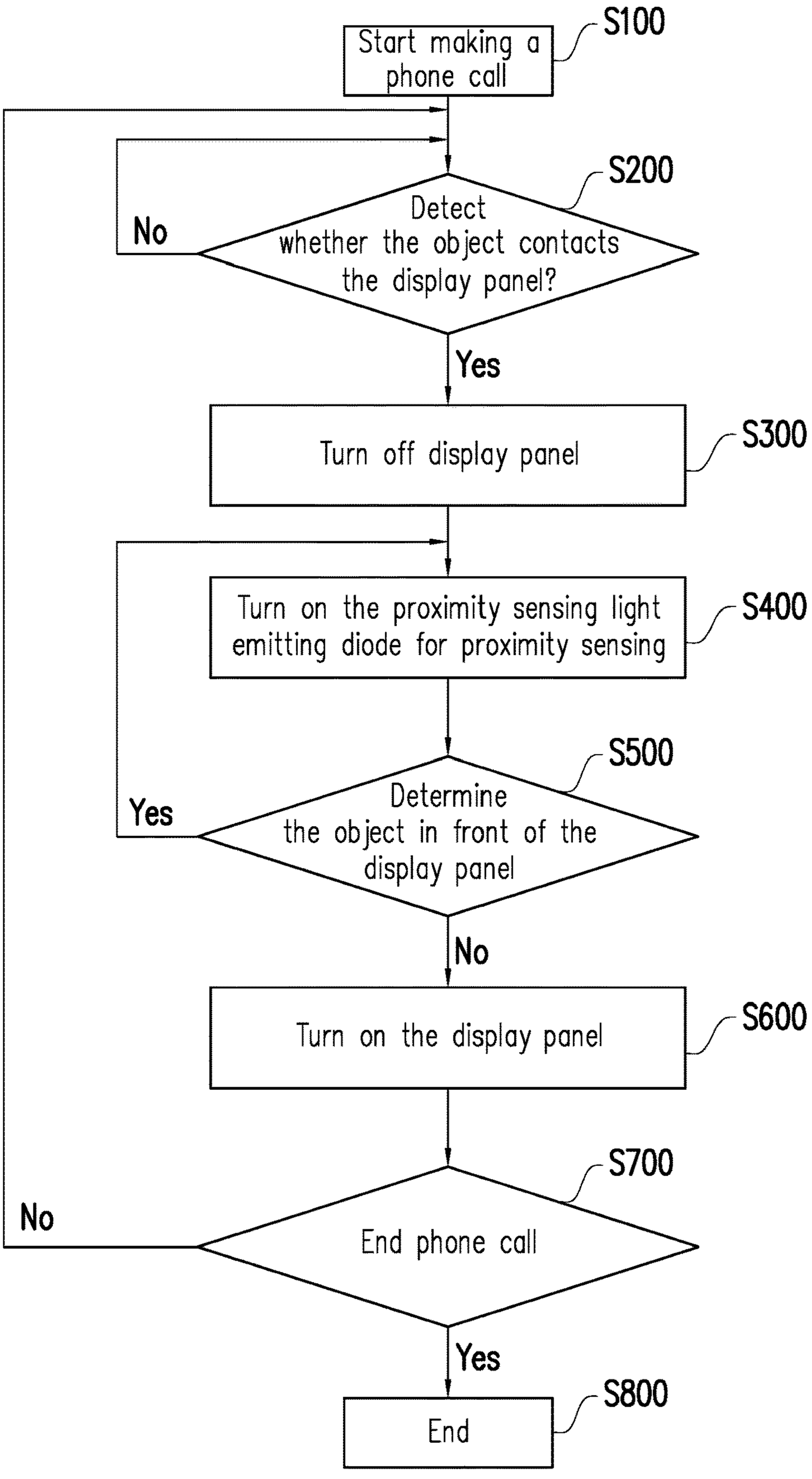
Start making a phone call
S100
Detect whether the object contacts the display panel?
S200
No
Yes
Turn off display panel
S300
Turn on the proximity sensing light emitting diode for proximity sensing
S400
Determine the object in front of the display panel
S500
Yes
No
Turn on the display panel
S600
End phone call
S700
No
Yes
End
S800

FIG. 8

FINGERPRINT AND PROXIMITY SENSING APPARATUS AND SENSING PROCESS THEREOF

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the priority benefits of U.S. provisional application Ser. No. 62/808,236, filed on Feb. 20, 2019. The entirety of the above-mentioned patent application is hereby incorporated by reference herein and made a part of this specification.

BACKGROUND

Technical Field

The disclosure relates to sensing apparatus and a sensing process, more specifically, to a fingerprint and proximity sensing apparatus and a sensing process thereof.

Description of Related Art

In the conventional way of using the under-display optical fingerprint sensor, a complementary metal oxide semiconductor (CMOS) image sensor is placed under display screen, which is an organic light-emitting diode display (OLED), of the mobile phone. The display screen of the mobile phone emits light onto the finger touching the display screen, so that the optical sensing array of the CMOS image sensor recognizes the fingerprint of the finger placed on the display screen of the mobile phone.

Further, the basic principle of the proximity sensor is to use the light-emitting diode (LED) on one side to emit light onto the object, and to receive the light by a photo-diode at the other side distant from the one side. The closer the distance is, the more sensing light can be received, so as to determine the distance from the object to the proximity sensor. Currently, the proximity sensor is often combined with an ambient light sensor and is placed at the area beside the front lens on the display screen of the mobile phone. In other words, it is still necessary to place two observation holes (for emitting light and receiving light) which have size and a distance therebetween in the display screen of the mobile phone. That is to say, the optical fingerprint sensor and proximity sensor are two separate components performing two different functions in the mobile phone.

SUMMARY

The disclosure is directed to a fingerprint and proximity sensing apparatus capable of performing both fingerprint recognizing function and proximity sensing function in order to increase the area for displaying image and reducing space and cost.

The disclosure is directed to a sensing process for the purpose of preventing the proximity sensing light emitting diode and the display panel from being turned on at the same time.

The disclosure provides a fingerprint and proximity sensing apparatus for fingerprint recognizing and proximity sensing. The fingerprint and proximity sensing apparatus includes a display panel, a fingerprint sensor, and a proximity sensing light emitting diode. The fingerprint sensor has an optical sensing array. The optical sensing array is configured to receive a first light emitted from the display panel and a second light emitted from the proximity sensing light emitting diode at different time periods. The first light and the second light have different ranges of wave length.

In one embodiment of the disclosure, the different time periods comprises a first time period and a second time period different from each other.

In one embodiment of the disclosure, in the first time period, an object is in contact with the display panel, the first light is emitted from the display panel and then is reflected by the object to the optical sensing array for fingerprint recognition.

In one embodiment of the disclosure, in the second time period, an object is in front of the display panel, the second light is emitted from the proximity sensing light emitting diode and then is reflected by the second object to the optical sensing array for proximity sensing.

In one embodiment of the disclosure, the proximity sensing light emitting diode is an infrared light emitting diode, and the second light emitted from the proximity sensing light emitting diode comprises an infrared light.

In one embodiment of the disclosure, the display panel comprises a light emitting diode display.

In one embodiment of the disclosure, the fingerprint sensor and the proximity sensing light emitting diode are disposed under the display panel.

In one embodiment of the disclosure, the proximity sensing light emitting diode is disposed adjacent to the optical sensing array of the fingerprint sensor.

In one embodiment of the disclosure, the proximity sensing light emitting diode is integrated with the fingerprint sensor.

In one embodiment of the disclosure, the fingerprint sensor is disposed in the display panel and the proximity sensing light emitting diode is disposed under the display panel.

In one embodiment of the disclosure, the optical sensing array includes a fingerprint sensing array and a proximity sensing array.

In one embodiment of the disclosure, the fingerprint sensing array and the proximity sensing array are separated from each other.

In one embodiment of the disclosure, the fingerprint sensing array and the proximity sensing array overlap with each other.

In one embodiment of the disclosure, the fingerprint and proximity sensing apparatus further includes an infrared light cut filter configured to block infrared light, and the infrared light cut filter is disposed on the fingerprint sensing array.

In one embodiment of the disclosure, the fingerprint and proximity sensing apparatus further includes an infrared filter configured to allow infrared light passing through, and the infrared filter is disposed on the proximity sensing array.

In one embodiment of the disclosure, the fingerprint sensing array and the proximity sensing array are driven by a same circuit.

The disclosure provides a fingerprint and proximity sensing apparatus for fingerprint recognizing and proximity sensing. The fingerprint and proximity sensing apparatus includes a display panel and a fingerprint sensor. The display panel includes a plurality of light emitting diodes (LEDs). The fingerprint sensor has an optical sensing array. The optical sensing array is configured to receive a first light and a second light emitted from the LEDs of the display panel at a first time period and a second time period, respectively. In the first time period, a first object is in contact with the display panel, the first light is emitted from the display panel and then is reflected by the first object to the optical sensing

array for fingerprint recognition. In the second time period, a second object is in front of but not in contact with the display panel, and the second light is emitted from the display panel and then is reflected by the second object to the optical sensing array for proximity sensing.

The disclosure provides a sensing process in a phone with a fingerprint and proximity sensing apparatus having a display panel, a fingerprint sensor, and a proximity sensing light emitting diode. The proximity sensing process includes steps of starting a phone call; detecting whether an object is in contact with the display panel; turning off the display panel when the object is in contact with the display panel; turning on the proximity sensing light emitting diode for proximity sensing; determining whether the object is in front of the display panel; turning on the display panel when the object is not in front of the display panel; determining whether the phone call is ended; and turning off the proximity sensing light emitting diode when the phone call is ended.

In one embodiment of the disclosure, the proximity sensing process further includes a step of continuing to detect when the object is not in contact with the display panel.

In one embodiment of the disclosure, the proximity sensing process further includes a step of continuing to turn on the proximity sensing light emitting diode for proximity sensing when the object is in front of the display panel.

In one embodiment of the disclosure, the proximity sensing process further includes a step of returning to detect whether the object is in contact with the display panel when the phone call is not ended.

Based on the above, in the embodiments of the disclosure, since the proximity sensing light emitting diode is disposed adjacent to the optical sensing array, the optical sensing array can be used to receive both the first light emitted from the display panel and the second light emitted from the proximity sensing light emitting diode at different time periods in order to perform both fingerprint recognizing function and proximity sensing function. That is to say, there is no need to have two different devices to respectively perform fingerprint recognizing function and proximity sensing function. To be more specific, it is not necessary to place a proximity sensor placed in the display panel, so the area of the display panel used for displaying image becomes bigger. For example, when the fingerprint and proximity sensing apparatus is applied to a smartphone, the proximity sensor is not placed at the area beside the front lens of the display panel of the smartphone. Therefore, the size of the area beside the front lens is reduced and thus save the space under the display panel of the smartphone.

In addition, the fingerprint sensing array and the proximity sensing array are driven by the same circuit, so as to reduce space (chip area) and cost.

To make the aforementioned more comprehensible, several embodiments accompanied with drawings are described in detail as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure.

FIG. **1** is a schematic top view of a fingerprint and proximity sensing apparatus according to one embodiment of the disclosure.

FIG. **2** is cross-sectional view of the fingerprint and proximity sensing apparatus of FIG. **1** at the first time period.

FIG. **3** is cross-sectional view of the fingerprint and proximity sensing apparatus of FIG. **1** at the second time period.

FIG. **4** is a three-dimensional schematic view of a fingerprint and proximity sensing apparatus according to another embodiment of the disclosure.

FIG. **5**A is a cross-sectional schematic view of a fingerprint and proximity sensing apparatus at the first time period according to another embodiment of the disclosure.

FIG. **5**B is a cross-sectional schematic view of the fingerprint and proximity sensing apparatus in FIG. **5**A at the second time period.

FIG. **6**A is cross-sectional schematic view of a fingerprint and proximity sensing apparatus at the first time period according to another embodiment of the disclosure.

FIG. **6**B is cross-sectional schematic view of the fingerprint and proximity sensing apparatus of FIG. **6**A at the second time period.

FIG. **7** is a schematic view of a driving circuit of a fingerprint and proximity sensing apparatus according to another embodiment of the disclosure.

FIG. **8** is a flow chart illustrating a sensing process using a fingerprint and proximity sensing apparatus according to another embodiment of the disclosure.

DESCRIPTION OF THE EMBODIMENTS

Reference will now be made in detail to the present preferred embodiments of the disclosure, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the description to refer to the same or like parts.

FIG. **1** is a schematic top view of a fingerprint and proximity sensing apparatus according to one embodiment of the disclosure. As shown in FIG. **1**, a fingerprint and proximity sensing apparatus **100** is used for both fingerprint recognizing and proximity sensing. The fingerprint and proximity sensing apparatus **100** includes a display panel **110**, a fingerprint sensor **120**, and at least one proximity sensing light emitting diode **130**. The fingerprint sensor **120** can have a sensing array such as an optical sensing array **121**. The optical sensing array **121** may include one or more photo-diodes. The proximity sensing light emitting diode **130** is disposed adjacent to the optical sensing array **121** of the fingerprint sensor **120**.

The optical sensing array **121** is configured to receive light (referred to as "first light") from the display panel **110** and light (referred to as "second light") from the proximity sensing light emitting diode **130** at different time periods. The first light L**1** and the second light L**2** have different ranges of wave length.

FIG. **2** is cross-sectional view of the fingerprint and proximity sensing apparatus of FIG. **1** at a first time period according to an embodiment. FIG. **3** is cross-sectional view of the fingerprint and proximity sensing apparatus of FIG. **1** at a second time period which is preferably (but not limitedly) different from the first time period according to an embodiment. Referring to FIG. **2** and FIG. **3**, the functions of fingerprint recognizing and proximity sensing will be further described. The optical sensing array **121** is configured to receive the first light L**1** from the display panel **110** and the second light L**2** from the proximity sensing light

emitting diode **130** at different time periods. The first light L**1** and the second light L**2** have different ranges of wave length.

To be more specific, the different time periods include the first time period T**1** and the second time period T**2** different from each other. In the first time period T**1**, there is an object touching the display panel **110**, and the fingerprint and proximity sensing apparatus **100** performs fingerprint recognizing function but may not perform proximity sensing function. Additionally, in the second time period T**2**, there is an object in front of the display panel **110** but not touching the display panel **110**, and the fingerprint and proximity sensing apparatus **100** performs proximity sensing function but may not perform fingerprint recognizing function.

In details, in the first time period T**1**, as shown in FIG. **2**, the first object **140***a* is in contact with the display panel **110** at a position corresponding to the optical sensing array **121**. The first object **140***a* may be a finger as an example, but the disclosure is not limited thereto. The display panel **110** includes a display and touch panel **111** and a transparent protective layer **112**. The display and touch panel **111** may include a light emitting diode display **111***a* which includes a plurality of organic light-emitting diodes (OLEDs) or a plurality of micro light emitting diodes (micro-LEDs). In other words, the light emitting diode display **111***a* may be an organic light-emitting diode display or a micro light emitting diode display, but the disclosure is not limited thereto. The first light L**1** is emitted from the light emitting diode display **111***a* of the display and touch panel **111** of the display panel **110** and is transmitted to the first object **140***a*. Next, the first light L**1** is reflected by the first object **140***a* and then passes through the gaps between the light emitting diodes of the light emitting diode display **111***a* to reach the optical sensing array **121**. That is to say, the fingerprint image of the first object **140***a* is reflected onto the optical sensing array **121** of the fingerprint sensor **120** by using the first light L**1**. Therefore, the fingerprint image of the first object **140***a* is obtained and the fingerprint recognizing function is accomplished. It should be noted here, the proximity sensing light emitting diode **130** is turned off in the in the first time period T**1**. Further, the fingerprint and proximity sensing apparatus **100** may be applied to smartphone, tablet or other similar electronic devices, the disclosure is not limited thereto. The first time period T**1** may be the time period that the user needs to provide the fingerprint for identification purpose, such as unlock the smartphone or unlock an app in the smartphone, etc.

In the second time period T**2**, as shown in FIG. **3**, the second object **140***b* is in front of the display panel **110**. The second object **140***b* may be the cheek of the user as an example, but the disclosure is not limited thereto. The second light L**2** is emitted from the proximity sensing light emitting diode **130** and is transmitted to the second object **140***b*. Next, the second light L**2** is reflected by the object **140***b* and then passes through the gaps between the light emitting diodes of the light emitting diode display **111***a* to reach the optical sensing array **121**. Therefore, the presence of the second object **140***b* is determined. Further, the larger the distance between the second object **140***b* and the display panel **110** is, the less second light L**2** is received by the optical sensing array **121**. In other words, the shorter the distance between the second object **140***b* and the display panel **110** is, the more second light L**2** is received by the optical sensing array **121**. Therefore, the distance between the second object **140***b* and the display panel **110** is determined according to the quantity or the brightness of the second light L**2** received by the optical sensing array **121**. Consequently, the presence of the second object **140***b* and the distance between the second object **140***b* and the display panel **110** are determined. However, in case that there is no object in front of the display panel **110**, the second light L**2** is not reflected and the optical sensing array **121** receives none of the second light L**2**. Therefore, the absence of the object in front of the display panel **110** is also determined. As a result, the proximity sensing function is accomplished.

In the present embodiment, the proximity sensing light emitting diode **130** is an infrared light emitting diode, so the second light L**2** emitted from the proximity sensing light emitting diode **130** is an infrared light. The first light L**1** is visible light emitted from the display panel **110**. In addition, the fingerprint sensor **120** and the proximity sensing light emitting diode **130** are disposed under the display panel **110**. In the present embodiment, not only the proximity sensing light emitting diode **130** is disposed adjacent to the optical sensing array **121** of the fingerprint sensor **120**, the proximity sensing light emitting diode **130** is also integrated with the fingerprint sensor **120**. To be more specific, as shown in FIG. **2** and FIG. **3**, the proximity sensing light emitting diode **130** is disposed in the fingerprint sensor **120**. However, the disclosure is not limited thereto. For example, in case that the fingerprint and proximity sensing apparatus **100** is applied to the smartphone, the second time period T**2** is the time period that the user are making a phone call.

Based on the above, since the proximity sensing light emitting diode **130** is disposed adjacent to the optical sensing array **121**, the optical sensing array **121** can be used to receive both the first light L**1** emitted from the display panel **110** and the second light L**2** emitted from the proximity sensing light emitting diode at different time periods in order to perform both fingerprint recognizing function and proximity sensing function. That is to say, there is no need to have two different devices to respectively perform fingerprint recognizing function and proximity sensing function. To be more specific, it is not necessary to place a proximity sensor placed in the display panel **110**, so the area of the display panel used for displaying image becomes larger. Take a smartphone as an example, when the fingerprint and proximity sensing apparatus **100** is applied to a smartphone, the proximity sensor is not placed at the area beside the front lens of the display panel of the smartphone. Therefore, the size of the area beside the front lens is reduced and thus save the space under the display panel of the smartphone.

FIG. **4** is a partial and three-dimensional schematic view of a fingerprint and proximity sensing apparatus according to another embodiment of the disclosure. A fingerprint and proximity sensing apparatus **100***a* in FIG. **4** is similar to the fingerprint and proximity sensing apparatus **100** of the previous embodiment, only the differences will be described hereinafter. Only the fingerprint sensor **120** and the proximity sensing light emitting diode **130** of the fingerprint and proximity sensing apparatus **100***a* are shown in FIG. **4**. As illustrated in FIG. **4**, the optical sensing array **121** of the fingerprint sensor **120** of the fingerprint and proximity sensing apparatus **100***a* includes a fingerprint sensing array **121***a* and a proximity sensing array **121***b*. The fingerprint sensing array **121***a* and the proximity sensing array **121***b* are separated from each other, but the disclosure is not limited thereto. Each of the fingerprint sensing array **121***a* and the proximity sensing array **121***b* includes one or more photodiodes.

Additionally, in the present embodiment, the fingerprint and proximity sensing apparatus **100***a* includes an infrared light cut filter **150***a* and an infrared filter **150***b*. The infrared

light cut filter **150***a* is configured to block infrared light and is disposed on the fingerprint sensing array **121***a*. The infrared filter **150***b* is configured to allow infrared light passing through and is disposed on the proximity sensing array **121***b*.

Therefore, in the first time period T**1**, when the first light L**1**, which is visible light and shown in FIG. **2**, is reflected by the first object **140***a* to the fingerprint sensor **120**, the first light L**1** passes through the infrared light cut filter **150***a* to reach the fingerprint sensing array **121***a* in order to obtain the fingerprint image of the first object **140***a*, and the first light L**1** is blocked by the infrared filter **150***b* and cannot reach the proximity sensing array **121***b*. In the second time period T**2**, when the second light L**2**, which is infrared light and shown in FIG. **3**, is reflected by the second object **140***b* to the fingerprint sensor **120**, the second light L**2** passes through the infrared filter **150***b* to reach the proximity sensing array **121***b* for sensing proximity of the second object **140***b*, and the second light L**2** is blocked by the infrared light cut filter **150***a* and cannot reach the fingerprint sensing array **121***a*. Therefore, the infrared light cut filter **150***a* and the infrared filter **150***b* are used for purpose of enhancing quality of the fingerprint image obtained in the first period and accuracy of proximity sensing in the second period.

In other embodiments, the fingerprint sensing array and the proximity sensing array may overlap with each other or may be combined with each other. The fingerprint sensing array and the proximity sensing array may be the same array which receives the first light and the second light at different time periods. It should be noted here, the purpose of receiving the first light and the second light at different time periods is enhancing quality of the fingerprint image and accuracy of proximity sensing.

FIG. **5**A is a cross-sectional schematic view of a fingerprint and proximity sensing apparatus at the first time period according to another embodiment of the disclosure. FIG. **5**B is a cross-sectional schematic view of the fingerprint and proximity sensing apparatus in FIG. **5**A at the second time period. A fingerprint and proximity sensing apparatus **100***b* in FIG. **5**A and FIG. **5**B is similar to the fingerprint and proximity sensing apparatus **100** in FIG. **2** and FIG. **3**, only the differences are described hereinafter. In the present embodiment, the fingerprint and proximity sensing apparatus **100***b* does not have the proximity sensing light emitting diode **130**, and the fingerprint sensor **120** performs both fingerprint recognizing and proximity sensing functions. To be more specific, the light emitting diode display **111***a* of the display panel **110** includes a plurality of light-emitting diodes (LEDs), such as organic light-emitting diodes (OLEDs) or micro light emitting diodes (micro-LEDs). The optical sensing array **121** of the fingerprint sensor **120** is configured to receive the first light L**1**, which is emitted from the LEDs of the light emitting diode display **111***a* of the display panel **110**, at the first time period T**1** and the second time period T**2**. For example, in case that the fingerprint and proximity sensing apparatus **100***b* is applied to the smartphone, the first time period T**1** is the time period that the user needs to provide the fingerprint for identification purpose, such as unlock the smartphone or unlock an app in the smartphone, etc., and the second time period T**2** is the time period that the user are making a phone call. That is to say, the fingerprint sensor **120** performs both fingerprint recognizing and proximity sensing functions at two different time periods.

In the first time period T**1**, for example, when the user needs to provide fingerprint to unlock the smartphone, the first object **140***a*, such as the finger of the user, is in contact with the display panel **110** at the position corresponding to the optical sensing array **121**, the first light L**1** is emitted from the light emitting diode display **111***a* of the display panel **110** and then is reflected by the first object **140***a* to the optical sensing array **121** for fingerprint recognition, as described in the previous embodiments. However, in the second time period T**2**, for example, when the user are making a phone call, the second object **140***b*, such as the cheek of the user, is in front of but not in contact with the display panel **110**, the first light L**1** is emitted from the light emitting diode display **111***a* of the display panel **110** and then is reflected by the second object **140***b* to the optical sensing array **121** for proximity sensing. That is to say, only the optical sensing array **121** and the first light L**1** emitted from the display panel **110** are exploited to perform both fingerprint recognizing and proximity sensing functions at two different time periods. Therefore, an additional proximity sensing light emitting diode is not required.

FIG. **6**A is cross-sectional schematic view of a fingerprint and proximity sensing apparatus at the first time period according to another embodiment of the disclosure. FIG. **6**B is cross-sectional schematic view of the fingerprint and proximity sensing apparatus of FIG. **6**A at the second time period. A fingerprint and proximity sensing apparatus **100***c* of the present embodiment is similar to the fingerprint and proximity sensing apparatus **100** in FIG. **2** and FIG. **3**, only the differences are described hereinafter. The fingerprint sensor **120** including the optical sensing array **121** is disposed in the display panel **110** and the proximity sensing light emitting diode **130** is disposed under the display panel **110**. In other words, the fingerprint sensor **120** is integrated with the display panel **110**.

FIG. **7** is a schematic view of a driving circuit of a fingerprint and proximity sensing apparatus according to another embodiment of the disclosure. The optical sensing array **121** includes the fingerprint sensing array **121***a* and the proximity sensing array **121***b*. In the embodiment, the fingerprint sensing array **121***a* and the proximity sensing array **121***b* are driven by a same circuit that is a driving circuit **200**. As shown in FIG. **7**, the driving circuit **200** includes a row driving circuit **210** and a column read-out circuit **220**. The photo diodes of the fingerprint sensing array **121***a* and the proximity sensing array **121***b* are driven by the row driving circuit **210** and the column read-out circuit **220** of the driving circuit **200**. In the present embodiment, the driving circuit **200** further includes an amplifier **230**, an analog digital converter **240**, and a calculating and transmitting unit **250**. The row driving circuit **210** and the column read-out circuit **220** are coupled to the amplifier **230**, the amplifier **230** is coupled to the analog digital converter **240**, and the analog digital converter **240** is coupled to the calculating and transmitting unit **250**. In other words, the amplifier **230**, the analog digital converter **240**, and the calculating and transmitting unit **250** are shared by the row driving circuit **210** and the column read-out circuit **220**, so as to reduce space (chip area) and cost. That is, the fingerprint sensing array **121***a* and the proximity sensing array **121***b* are driven by the same circuit, so as to reduce space (chip area) and cost.

It should be noted here, the row driving circuit **210** provides control signals for the optical sensing array **121**, so as to provide photo-sensitive reset signals (rst), photo-sensitive output signals (tx), or select signals (sel) for each row of the photo diodes (or sensing pixels) in sequence. When selectively receiving these signals, the light sensing

voltage of the photo diode (or sensing pixel) can be reset, the photo diode (or sensing pixel) can be exposed and output signal.

When the row driving circuit **210** provides the photo-sensitive output signals (tx) for an entire row of photo diodes (or sensing pixels), each of the photo diodes (or sensing pixels) in the entire row of photo diodes outputs signal to the column read-out circuit **220**. Simultaneously, the column read-out circuit **220** samples the signal outputted from the photo diodes and sequentially outputs the signals (voltages) obtained by each of the photo diodes in the entire row of photo diodes to the amplifier **230** through a multiplexer. After that, the signals are amplified by the amplifier **230** and then are provided to the analog digital converter **240** to be converted to digital signals. Next, the digital signals are provided to the calculating and transmitting unit **250** for other operations.

For example, the row driving circuit **210** provides signals for the fingerprint sensing array **121***a* in the first time period T**1** and provides the signals for the proximity sensing array **121***b* in the second time period T**2**. The column read-out circuit **220** receives the first sensing signals from the fingerprint sensing array **121***a* in the first time period T**1** and receives the second sensing signals from the proximity sensing array **121***b* in the second time period T**2**. It should be noted here, the first time period T**1** and the second time period T**2** are different from each other. The amplifier **230** receives and amplifies the first sensing signals and the second sensing signals from the column read-out circuit **220** to obtain the first amplified sensing signals and the second amplified sensing signals. The analog digital converter **240** receives and converts the first amplified sensing signals and the second amplified sensing signals to the first converted sensing signals and the second converted sensing signals. Finally, the calculating and transmitting unit **250** receives the first converted sensing signals and the second converted sensing signals for other operations, such as fingerprint recognizing or proximity sensing.

Therefore, through the row driving circuit **210** selecting the row of photo diodes, the fingerprint sensing array **121***a* or the proximity sensing array **121***b* can be selected to be exposed and then output signals. When the proximity sensing function is performed, the photo diodes of the proximity sensing array **121***b* are reset to reset voltage, are exposed, and then output signals to the column read-out circuit **220**. At this time, the signals provided for the amplifier **230** from the column read-out circuit **220** are signals required for proximity sensing. In addition, when the fingerprint recognizing function is performed, the photo diodes of the fingerprint sensing array **121***a* are reset to a reset voltage and exposed, and then output signals to the column read-out circuit **220**. At this time, the signals received by the column read-out circuit **220** are signals required for fingerprint recognizing.

In the present embodiment, the fingerprint sensing array **121***a* and the proximity sensing array **121***b* are driven, according to a time-division scheme, by the same circuit which includes the amplifier **230**, the analog digital converter **240**, and the calculating and transmitting unit **250**. However, the disclosure is not limited thereto. In other embodiments, the fingerprint sensing array **121***a* and the proximity sensing array **121***b* are respectively driven by two different circuits which can totally separate circuits or partially integrated circuits.

FIG. **8** is a flow chart illustrating a sensing process using a fingerprint and proximity sensing apparatus according to another embodiment of the disclosure. In the present embodiment, any of the fingerprint and proximity sensing apparatuses **100**, **100***a*, and **100***b* mentioned above is applied to a smartphone and is call "the fingerprint and proximity sensing apparatus". In other embodiments, the fingerprint and proximity sensing apparatus may be applied to a tablet or computer with touch screen, etc., but the disclosure is not limited thereto.

In step S**100**, the user use the smartphone to start making a phone call. At this time the fingerprint and proximity sensing apparatus detects whether an object is in contact with the display panel **110**, as shown in step S**200**. The object may be the face or the cheek of the user. If the result is "no", it means that the object is not in contact with the display panel **110**. When the object is not in contact with the display panel **110**, the fingerprint and proximity sensing apparatus continues to detect, and the step S**200** is still performed. If the result is "yes", it means that the object is in contact with the display panel **110**. When the object is in contact with the display panel **110**, the display panel **110** is turned off as mentioned in step **5300**.

Next, in step S**400**, the proximity sensing light emitting diode **130** is turned on for proximity sensing. To be more specific, the proximity sensing light emitting diode **130** emits the second light L**2** (infrared light) after being turned on. In step S**500**, it is determined whether there is the object is in front of the display panel **110** according to whether the optical sensing array **121** receives the second light L**2** or not. To be more specific, when the optical sensing array **121** receives the second light L**2**, the result is "yes", it means that the user is still making the phone call and the user's face or cheek is close to the display panel **110**. At this time, the proximity sensing light emitting diode **130** is continuously turned on for proximity sensing and it is returned to step S**400**. When the optical sensing array **121** does not receive the second light L**2**, the result is "no", it means that the user is still making the phone call, but the user's face or cheek is not close to the display panel **110**. The user may be need to look at some information stored in the smartphone, so the display panel **110** is turned on as mentioned in step S**600**.

Further, in step S**700**, it is determined whether the phone call is ended. If the result is "no", it means that the phone call is not ended. It is returned to step S**200** to detect whether the object is in contact with the display panel **110**. If the result is "yes", it means that the phone call is ended, and the proximity sensing light emitting diode **130** is turned off as mentioned in step S**800**. The purpose of this sensing process (or proximity sensing process) is to prevent the proximity sensing light emitting diode **130** and the display panel **110** from being turned on at the same time.

In summary, in the embodiments of the disclosure, since the proximity sensing light emitting diode is disposed adjacent to the optical sensing array, the optical sensing array can be used to receive both the first light emitted from the display panel and the second light emitted from the proximity sensing light emitting diode at different time periods in order to perform both fingerprint recognizing function and proximity sensing function. That is to say, there is no need to have two totally different devices to respectively perform fingerprint recognizing function and proximity sensing function, but more devices and/or circuit can be used in common. To be more specific, it is not necessary to place a proximity sensor placed in the display panel, so the area for displaying image of the display panel becomes larger. For example, when the fingerprint and proximity sensing apparatus is applied to a smartphone, the proximity sensor is not placed at the area beside the front lens of the display panel of the

smartphone. Therefore, the size of the area beside the front lens is reduced and thus save the space under the display panel of the smartphone.

In addition, the fingerprint sensing array and the proximity sensing array are driven by the same circuit, so as to reduce space (chip area) and cost. Further, the sensing process using the fingerprint and proximity sensing apparatus is for the purpose of preventing the proximity sensing light emitting diode and the display panel from being turned on at the same time.

It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed embodiments without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the disclosure covers modifications and variations provided that they fall within the scope of the following claims and their equivalents.

What is claimed is:

1. A fingerprint and proximity sensing apparatus, for fingerprint recognizing and proximity sensing, comprising:

a display panel;

a fingerprint sensor having an optical sensing array; and

at least one proximity sensing light emitting diode, wherein the optical sensing array is configured to receive a first light emitted from the display panel and a second light emitted from the at least one proximity sensing light emitting diode at different time periods, thereby separately performing the fingerprint recognizing and the proximity sensing,

wherein the first light and the second light have different ranges of wave length.

2. The fingerprint and proximity sensing apparatus as recited in claim **1**, wherein the different time periods comprises a first time period and a second time period different from each other.

3. The fingerprint and proximity sensing apparatus as recited in claim **2**, wherein, in the first time period, an object is in contact with the display panel, the first light is emitted from the display panel and then is reflected by the object to the optical sensing array for fingerprint recognition.

4. The fingerprint and proximity sensing apparatus as recited in claim **2**, wherein, in the second time period, an object is in front of the display panel, the second light is emitted from the at least one proximity sensing light emitting diode and then is reflected by a second object to the optical sensing array for proximity sensing.

5. The fingerprint and proximity sensing apparatus as recited in claim **1**, wherein the at least one proximity sensing light emitting diode is an infrared light emitting diode, and the second light emitted from the at least one proximity sensing light emitting diode comprises an infrared light.

6. The fingerprint and proximity sensing apparatus as recited in claim **1**, wherein the display panel comprises a light emitting diode display.

7. The fingerprint and proximity sensing apparatus as recited in claim **1**, wherein the fingerprint sensor and the at least one proximity sensing light emitting diode are disposed under the display panel.

8. The fingerprint and proximity sensing apparatus as recited in claim **7**, wherein the at least one proximity sensing light emitting diode is disposed adjacent to the optical sensing array of the fingerprint sensor.

9. The fingerprint and proximity sensing apparatus as recited in claim **7**, wherein the at least one proximity sensing light emitting diode is integrated with the fingerprint sensor.

10. The fingerprint and proximity sensing apparatus as recited in claim **1**, wherein the fingerprint sensor is disposed in the display panel and the at least one proximity sensing light emitting diode is disposed under the display panel.

11. The fingerprint and proximity sensing apparatus as recited in claim **1**, wherein the optical sensing array comprises a fingerprint sensing array and a proximity sensing array.

12. The fingerprint and proximity sensing apparatus as recited in claim **11**, wherein the fingerprint sensing array and the proximity sensing array are separated from each other.

13. The fingerprint and proximity sensing apparatus as recited in claim **11**, wherein the fingerprint sensing array and the proximity sensing array overlap with each other.

14. The fingerprint and proximity sensing apparatus as recited in claim **11**, further comprising an infrared light cut filter configured to block infrared light, wherein the infrared light cut filter is disposed on the fingerprint sensing array.

15. The fingerprint and proximity sensing apparatus as recited in claim **11**, further comprising an infrared filter configured to allow infrared light passing through, and the infrared filter is disposed on the proximity sensing array.

16. The fingerprint and proximity sensing apparatus as recited in claim **11**, wherein the fingerprint sensing array and the proximity sensing array are driven by a same circuit.

17. A fingerprint and proximity sensing apparatus, for fingerprint recognizing and proximity sensing, comprising:

a display panel comprising a plurality of light emitting diodes (LEDs); and

a fingerprint sensor having an optical sensing array, wherein the optical sensing array is configured to receive a first light and a second light emitted from the LEDs of the display panel at a first time period and a second time period, respectively,

wherein, in the first time period, a first object is in contact with the display panel, the first light is emitted from the display panel and then is reflected by the first object to the optical sensing array for fingerprint recognition, and

wherein, in the second time period, a second object is in front of but not in contact with the display panel, the second light is emitted from the display panel and then is reflected by the second object to the optical sensing array for proximity sensing, whereby the fingerprint recognizing and the proximity sensing are performed separately.

18. A data processing apparatus, configured to drive a sensing array of a fingerprint and proximity sensing apparatus, the sensing array comprising a fingerprint sensing array and a proximity sensing array, the data processing apparatus comprises:

a row driving circuit, providing signals for the fingerprint sensing array in a first time period and providing the signals for the proximity sensing array in a second time period, wherein in the second time period, the row driving circuit does not provide the signals for the fingerprint sensing array; and

a column read-out circuit, receiving first sensing signals from the fingerprint sensing array in the first time period and receiving second sensing signals from the proximity sensing array in the second time period, wherein the first time period and the second time period are different from each other, and in the second time period, the column read-out circuit does not receive the first sensing signals for the fingerprint sensing array.

19. The data processing apparatus as recited in the claim **18**, further comprising:

an amplifier, receiving and amplifying the first sensing signals and the second sensing signals from the column

read-out circuit to obtain first amplified sensing signals and second amplified sensing signals, respectively;

an analog digital converter, receiving and converting the first amplified sensing signals and the second amplified sensing signals to first converted sensing signals and second converted sensing signals; and

a calculating and transmitting unit, receiving the first converted sensing signals and the second converted sensing signals.

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